Computational Prediction of Targeted Temperature Management Outcome for Personalized Cardiac Arrest Treatment

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INTRODUCTION

Targeted temperature management (TTM) is associated with higher odds of neurological recovery in comatose survivors of cardiac arrest. However, the efficacy of TTM is not consistently observed, possibly due to heterogeneity of treatment effects. The aim of this study is to determine if models leveraging granular data available in the first 6 hours after ICU admission (hyperacute phase) can predict short-term outcomes after TTM.

METHODS

969 adult patients receiving TTM after cardiac arrest were selected from the multicenter Philips eICU database. Predictive features were extracted from clinical, physiologic, and laboratory data available in the hyperacute phase. Primary endpoints were survival and favorable neurological outcome, determined as a motor Glasgow Coma Scale (mGCS) of 6 upon discharge. Three machine learning algorithms were trained: generalized linear model (GLM), random forest (RF), and gradient boosting (XGBoost). Models with optimal features from forward selection with threshold of 0.5 for mortality prediction and threshold of 1 for prediction of favorable neurological outcome were 10-fold cross-validated and resampled 10 times.

RESULTS

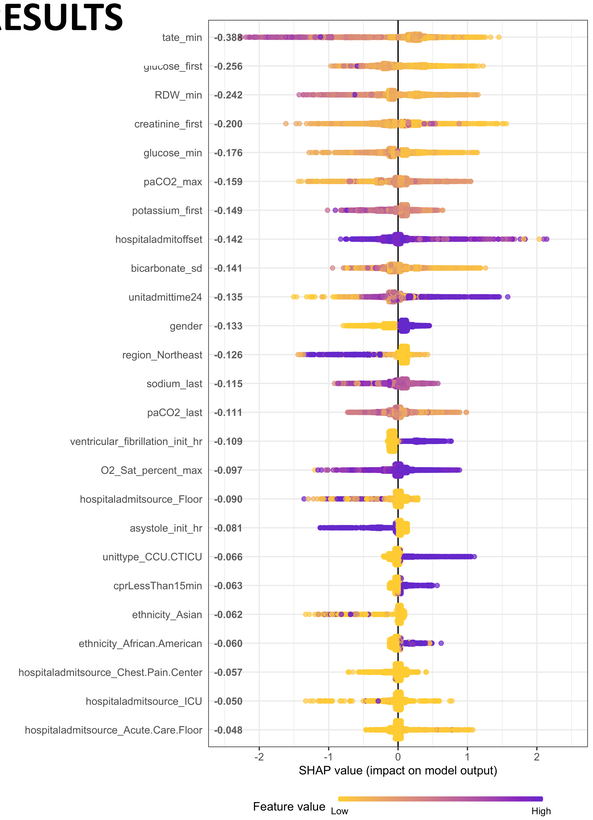

Fig 1. Selection of top 25 features correlated with mortality, with (+) SHAP values indicating survival and (-) SHAP values indicating death at the time of discharge. Higher maximum O_2 saturation and CPR duration < 15 min were correlated with survival.

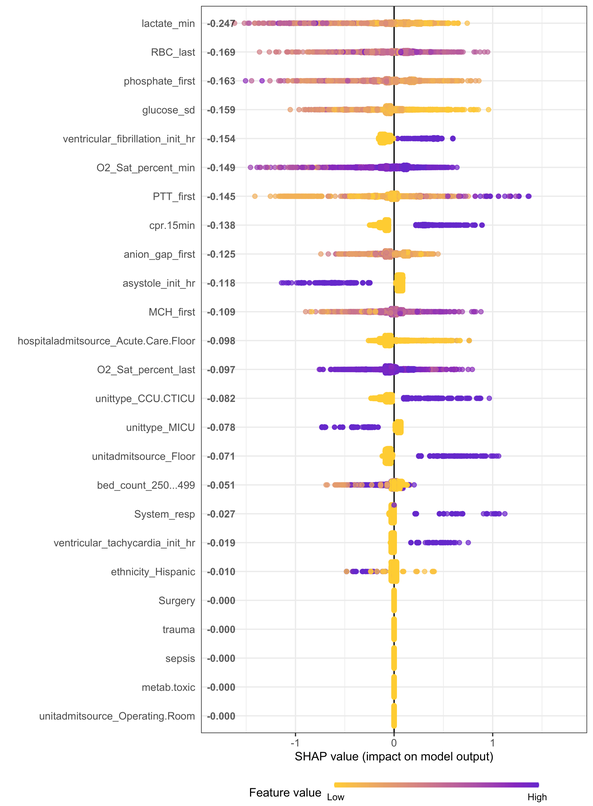

Fig 2. Selection of top 25 features correlated with mGCS, with (+) SHAP values indicating mGCS of 6 and (-) SHAP values indicating mGCS less than 6 at the time of discharge. Initial heart rates of ventricular fibrillation and ventricular tachycardia were correlated with mGCS of 6.

	AUROC	Sensitivity	Specificity
XGboost	0.686 ± 0.036	0.669 ± 0.149	0.602 ± 0.155
RF	0.703 ± 0.031	0.604 ± 0.110	0.672 ± 0.082
GLM	0.716 ± 0.035	0.639 ± 0.065	0.678 ± 0.082

Table 1. Summary of performance metrics for predicting mortality status upon discharge. After selecting features with a threshold above 0.5, GLM providing optimized performance, with AUROC of 0.716 ± 0.035.

	AUROC	Sensitivity	Specificity
XGboost	0.629 ± 0.029	0.622 ± 0.130	0.538 ± 0.168
RF	0.675 ± 0.032	0.646 ± 0.098	0.610 ± 0.104
GLM	0.681 ± 0.026	0.663 ± 0.139	0.617 ± 0.112

Table 2. Summary of performance metrics for predicting neurological status upon discharge. After selecting features with a threshold above 1, GLM providing optimized performance, with AUROC of 0.681 ± 0.026.

CONCLUSIONS

In patients receiving TTM after cardiac arrest, short-term outcomes can be predicted with data routinely collected in the first 6 hours after ICU admission. Model performance was moderately accurate but might increase with ongoing analysis of different observation windows and additional predictor variables. Hyperacute prediction could increase the effectiveness of clinical decision-making in the post-cardiac arrest setting.

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